An Investigation of the Mechanical Properties of Concrete with Microfibers

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ABSTRACT

Concrete is a material on which most all structures are constructed. Beneath every stable structure is a solid foundation, one made of concrete. Concrete has the innate ability to withstand high compressive forces; however, it does not possess the same strength against tensile forces. To compensate for this lack of tensile strength, steel rebar is often used. In addition to steel rebar, the use of microfibers in the design of concrete are becoming a topic of interest. During this investigation two concrete samples are designed. One unreinforced concrete sample and another reinforced with carbon microfibers. Samples are then put through various tests. Including tests for workability, compressive strength and tensile strength. The results of these tests compared the values determined for the sample reinforced with carbon microfibers to those of the unreinforced sample. Utilizing the results of these tests can give us a better understanding of the effects of adding different microfibers to concrete. This done in the hopes of producing new innovations in the design of concrete. Innovations that will allow the use of better designed concrete for safer construction in the community. This research has been funded through an Undergraduate Research fellowship.

BACKGROUND

While the uses of these fibers are an ever-growing field of research, it is not a new concept. Prior to the 1970's Asbestos was a commonly used concrete reinforcement; though the discovery of is carcinogenic properties led to the end of its use, it also sparked the search for a fiber able to replace it. In the decade that followed micro-fibers made from carbon, steel and synthetic material filled this void.

Carbon fibers, as were used for this investigation, have been know to increase tensile and flexural strength of concrete. Some case studies have shown a decrease in compressive strength. In addition to changes in strength, the fibers have been known to reduce the workability of concrete. Since concrete is naturally adept in regards to compressive strength this potential loss is negligible.

The use of these fibers are presently limited by economic feasibility in large scale applications, however through further testing, research and support, microfiber reinforced concrete may one day become a standard practice in the construction industry.

MATERIALS

- Portland Cement
- Course Aggregate possessing a max nominal size of 12.5mm
- Fine Aggregate possessing a max nominal size of 4.75 mm
- Zoltek PX35 Chopped Carbon Fibers

Photographic Representation of Zoltek Carbon Fibers

PHOTOS

Slump Test of M0

Slump Test of M0.5

Slump Test of M1

Slump Test of M1.5

Slump Test of M2

Compressive Strength Test result of M0

Compressive Strength Test result of M1

Tensile Strength Test result of M0

Tensile Strength Test result of M1

TABULATED RESULTS

Table 1. Slump Test Values

	Slump (mm)	Slump (in)
M0	85	3.35
M0.5	61	2.40
M1	48	1.89
M1.5	38	1.50
M2	13	0.51

Reinforcement	Cyl. Diam. (mm)	Height (mm)	Age (days)	Load at Break (kN)	Stress at Break (Mpa)
Unreinforced	150	300	28	721.99	40.88
Unreinforced	150	300	28	764.54	43.29
M0.5	150	300	28	Pending	0.00
M1	150	300	28	820.57	46.46
M1.5	150	300	28	Pending	0.00
M2	150	300	28	Pending	0.00

Table 2. Compressive Strength Test Values

Reinforcement	Cyl. Diam. (mm)	Height (mm)	Age (days)	Load at Break (kN)	Tensile Strength (Mpa)
Unreinforced	150	300	28	152.16	2.15
Unreinforced	150	300	28	143.95	2.04
M0.5	150	300	28	Pending	0.00
M1	150	300	28	241.57	3.42
M1.5	150	300	28	Pending	0.00
M2	150	300	28	Pending	0.00

Table 3. Tensile Strength Test Values

Reinforcement	Width (mm)	Depth (mm)	Height (mm)	Age (days)	Load at Break (kN)	MOR (Mpa)
Unreinforced	150	150	450	28	41.63	5.55
M0.5	150	150	450	28	Pending	0.00
M1	150	150	450	28	42.99	5.73
M1.5	150	150	450	28	Pending	0.00
M2	150	150	450	28	Pending	0.00

Table 4. Flexural Strength Test Values

METHODS

- Properties of Materials
  - Sieve Analysis (ASTM C 136)
  - Fineness Modulus (ASTM C 125)
  - SG of Fine Aggregate (ASTM C 127)
  - SG of Course Aggregate (ASTM C 128)
- Mixing / Testing
  - Mix Design (ACI 211.1)
  - Slump Test (ASTM C 143)
  - 28 Day Curing Process (ASTM C 31)
  - Compressive Strength Test (ASTM C 39)
  - Tensile Strength Test (ASTM C 496)
  - Flexural Strength Test (ASTM C 1609)

CONCLUSION

Based on the data collected by completed testing of M0 and M1 it can be assumed there is a direct correlation between the introduction of carbon microfibers into the concrete mixture and the increase in tensile, flexural strength and even compressive of the concrete.

Testing of the concrete mixtures M0.5, M1.5 and M2 have yet to be completed so a final analytical conclusion will not be made until all testing data has been collected. Assuming the remaining tests follow the same trend as the results from the previous tests the results of this investigation will further support the possible advantages that microfiber reinforced concrete could offer.

REFERENCES

- ACI Committee 211.1–91 2017. " Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete". ACI 211.1-91, Farmington Hills, MI.
- ASTM Standard C31/C31M–18. 2012. "Standard Practice for Making and Curing Concrete Test Specimens in the Field" , ASTM International, West Conshohocken, PA.
- ASTM Standard C39/C39M–18. 2018. "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens" , ASTM International, West Conshohocken, PA.
- ASTM Standard C125–15. 2018. "Standard Terminology Relating to Concrete and Concrete Aggregates" , ASTM International, West Conshohocken, PA.
- ASTM Standard C127-12. 2018. "Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate" , ASTM International, West Conshohocken, PA.
- ASTM Standard C128–15. 2018. "Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate" , ASTM International, West Conshohocken, PA.
- ASTM Standard C136/C136M–14. 2018. "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates" , ASTM International, West Conshohocken, PA.
- ASTM Standard C496/C496M–17. 2012. "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens" , ASTM International, West Conshohocken, PA.
- ASTM Standard C1609/C1609M–12. 2012. "Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)" , ASTM International, West Conshohocken, PA.